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I R E A P S

APPLICATION OF SHIPOPT TO PRELIMINARY DESIGN OF COMMERCIAL SHIPS

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Mr. Moore has over 5 years experience in the design of vehicles and platforms for the marine environment. He is actively involved in ocean platform and ship design and analysis, including development and evaluation of platform concepts for shelf-mounted ocean thermal energy conversion (OTEC) systems, and has been involved in various ship design and modification projects, structural engineering calculations, including finite element analysis procedures and intact and damaged stability studies.

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Mr. Maris holds a Professional Engineers License in Naval Architecture and Marine Engineering from Washington State, a bachelors degree (naval architecture/marine engineering) from the University of Michigan, a masters of engineering degree (naval architecture) from the University of California, and has completed business management studies at the University of California. He is a member of the American Bureau of Shipping Special Committee for OTEC and the Society of Naval Architects (Northern California) Executive Committee.

ABSTRACT

The theory and results of applying computer-aided ship structure optimization procedures to design of a.new.ferry for southwestern Alaska routes is presented, and.is called SHIPOPT. It has been developed by Professor Owen Hughes of the University of New South Wales, Australia, and has had recent application by Giannotti and Associates Inc, to structural design of U.S. Navy ships. Ship optimization is a rationally based, interactive procedure which recognizes prescribed design constraints and optimizes within those constraints ship structural scantlings and geometry for strength, weight, and cost. The structural constraints typically considered are allowable shear and bending stresses, buckling loads, fatigue life, weight, and ship arrangements, based on commercial or regulatory body requirements.

1) SCOPE

2) METHODOLOGY

3) APPLICATION (GENERAL) OF SHIPOPT

4) APPLICATION (SPECIFIC) OF SHIPOPT

5) ACCESSIBILITY/HARDWARE REQUIREMENTS

SHIPOPT PROVIDES:

- A RATIONALLY BASED TOOL FOR PRELIMINARY SHIP DESIGN THROUGH;
- A FAST, EFFICIENT, LOW COST, STRUCTURAL ANALYSIS AND OPTIMIZATION PROGRAM WHICH;
- ALLOWS DESIGNER INPUT OF SAFETY AND FUNCTIONAL CONSTRAINTS AND OPTIMIZATION MEASURES OF MERIT,

RATIONALLY BASED PRELIMINARY
STRUCTURAL DESIGN

1) RESPONSE ANALYSIS

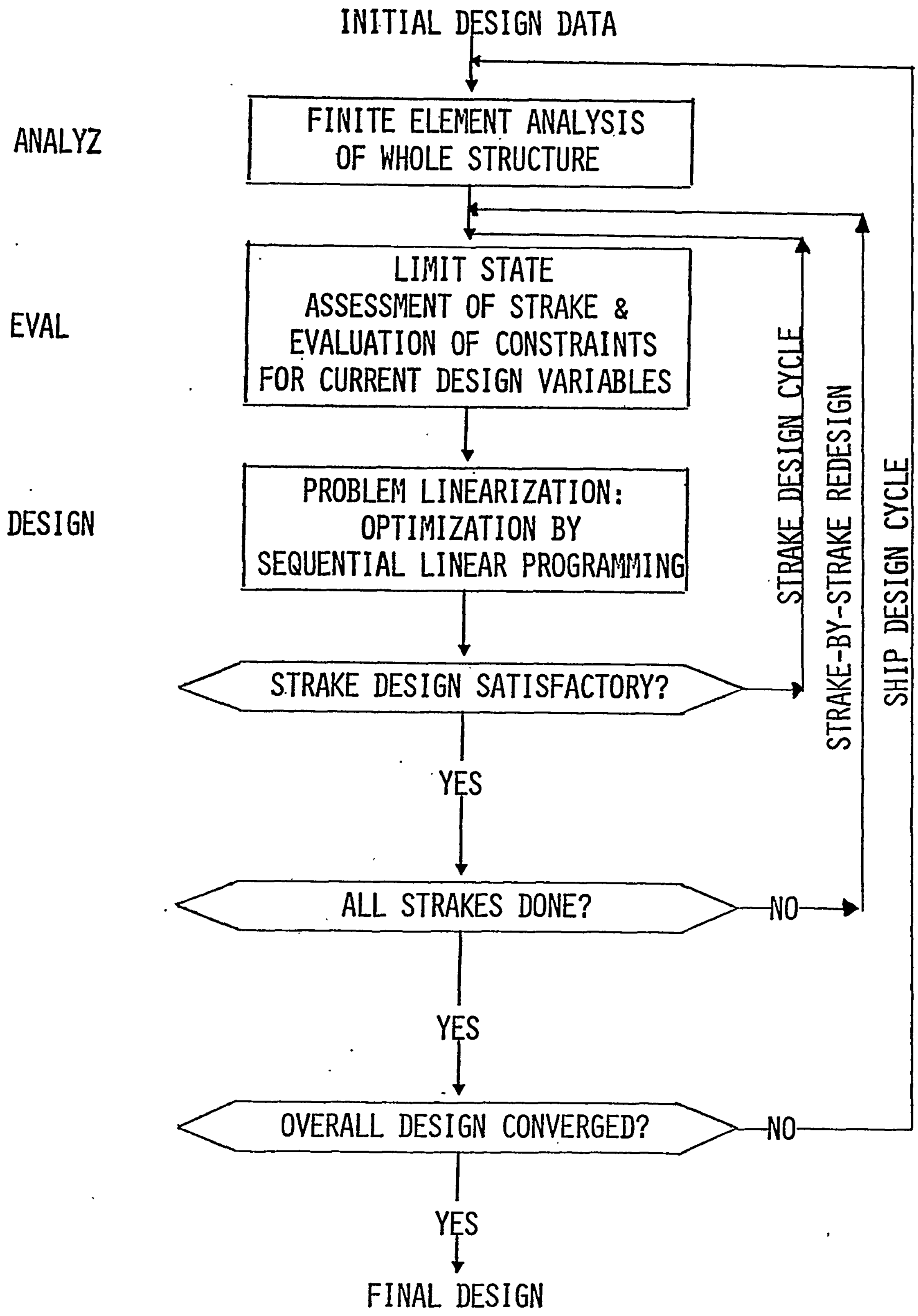
2) CAPABILITY (OR LIMIT STATE) ANALYSIS

3) RELIABILITY BASED STRENGTH CRITERIA

4) NONSTRUCTURAL CRITERIA

5) OPTIMIZATION

6) INTERACTIVE MODE OF OPERATION



INITIAL DESIGN DATA
ANALYZ
FINITE ELEMENT ANALYSIS OF WHOLE STRUCTURE
EVAL
LIMIT STATE ASSESSMENT OF STRAKE & EVALUATION OF CONSTRAINTS FOR CURRENT DESIGN VARIABLES
DESIGN
PROBLEM LINEARIZATION: OPTIMIZATION BY SEQUENTIAL LINEAR PROGRAMMING
STRAKE DESIGN SATISFACTORY?
YES
ALL STRAKES DONE?
NO
YES
OVERALL DESIGN CONVERGED?
NO
YES
FINAL DESIGN
STRAKE DESIGN CYCLE
STRAKE-BY-STRAKE REDESIGN
SHIP DESIGN CYCLE

APPLICATION (GENERAL) OF SHIPOPT

- BENEFITS
- LIMITATIONS
- STARTING POINT
- RESULTS

BENEFITS (OF STRUCTURAL ANALYSIS>

- STRUCTURAL ASSESSMENT AND DESIGN REVIEW
- INVESTIGATION OF SAFETY FACTORS
- INVESTIGATION OF ALTERNATIVE DESIGN LOADS
- ASSESSMENT OF STRUCTURAL DAMAGE OR CORROSION

BENEFITS (OF OPTIMIZATION)

l FIRST ORDER

- REDUCED COST AND WEIGHT
- INCREASED PERFORMANCE (E.G., LOWER VCG)
- COST VS. WEIGHT

l SECOND ORDER

- REDUCED WEIGHT IMPLIES LOWER RESISTANCE THUS LOWER MACHINERY WEIGHTS

l THIRD ORDER

- REDUCED MACHINERY WEIGHT IMPLIES FURTHER REDUCTION IN LOCAL SCANTLINGS, OVERALL WEIGHT, RESISTANCE AND COST

SHIPOPT ABILITIES

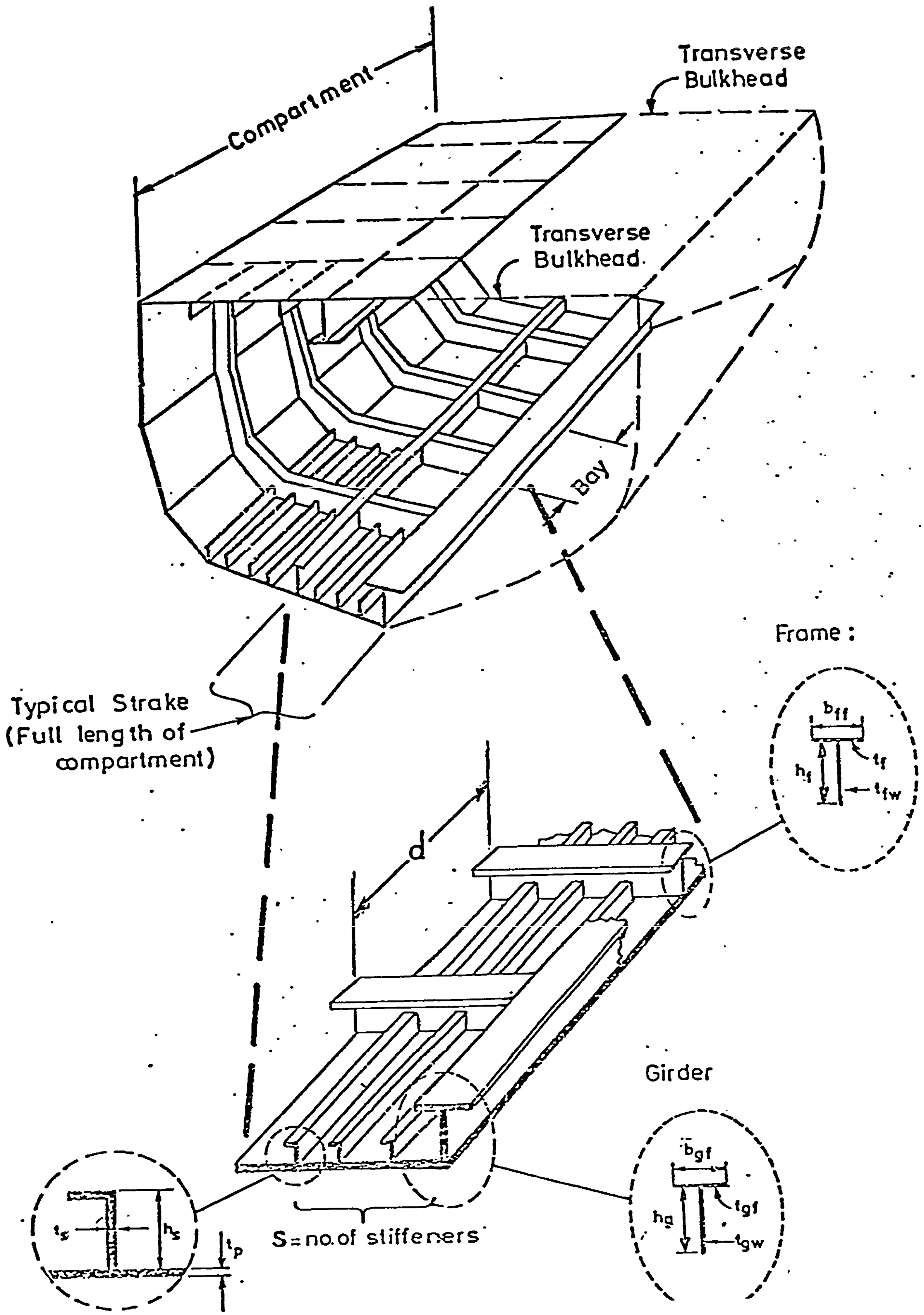
- COMPREHENSIVE 3-D STRUCTURAL ANALYSIS AT EACH STAGE
- EXPLICIT CALCULATION OF ULTIMATE STRENGTH OF ALL PRINCIPAL MEMBERS
- FAST CYCLE TIME
- ABILITY TO REPEAT A PRELIMINARY DESIGN
- ALTERNATIVE STRUCTURAL CONFIGURATIONS
- STANDARD SECTIONS
- USER DEFINED MEASURE OF MERIT; CONSTRAINTS

LIMITATIONS

- PRISMATIC MODEL
- SYMMETRIC ABOUT ℄
- STATIC OR QUASI-STATIC LOADING ONLY

STARTING POINT

- LOADS
- STRUCTURAL DEFINITION
  - STIFFENERS AND PLATES
  - STRAKES
  - BHDS,
  - MODULE
- CONSTRAINTS
- PARTIAL SAFETY FACTORS



Compartment
Transverse Bulkhead
Transverse Bulkhead
Bay
Frame :
b_{ff}
t_f
h_f
t_{fw}
Typical Strake (Full length of compartment)
d
Girder
b_{gf}
t_{gf}
h_g
t_{gw}
t_s
h_s
t_p
S = no. of stiffeners

RESULTS

- ANALYSIS
  - NODAL DEFLECTIONS
  - STRESSES
  - MINIMUM CONSTRAINTS FUNCTION LOCATION IN STRAKE
  - STATISTICAL FEASIBILITY SUMMARY

RESULTS

- OPTIMIZATION
  - CONSTRAINT FUNCTION VALUES
  - ACTIVE CONSTRAINTS
  - STATISTICAL FEASIBILITY SUMMARY

APPLICATION (SPECIFIC)

- TEST CASES
- ALASKA FERRY
  - **HULL CUTOUTS**
  - **VEHICLE DECK**
  - **SUPERSTRUCTURE**
  - **EXTREME HEAVY WEATHER**

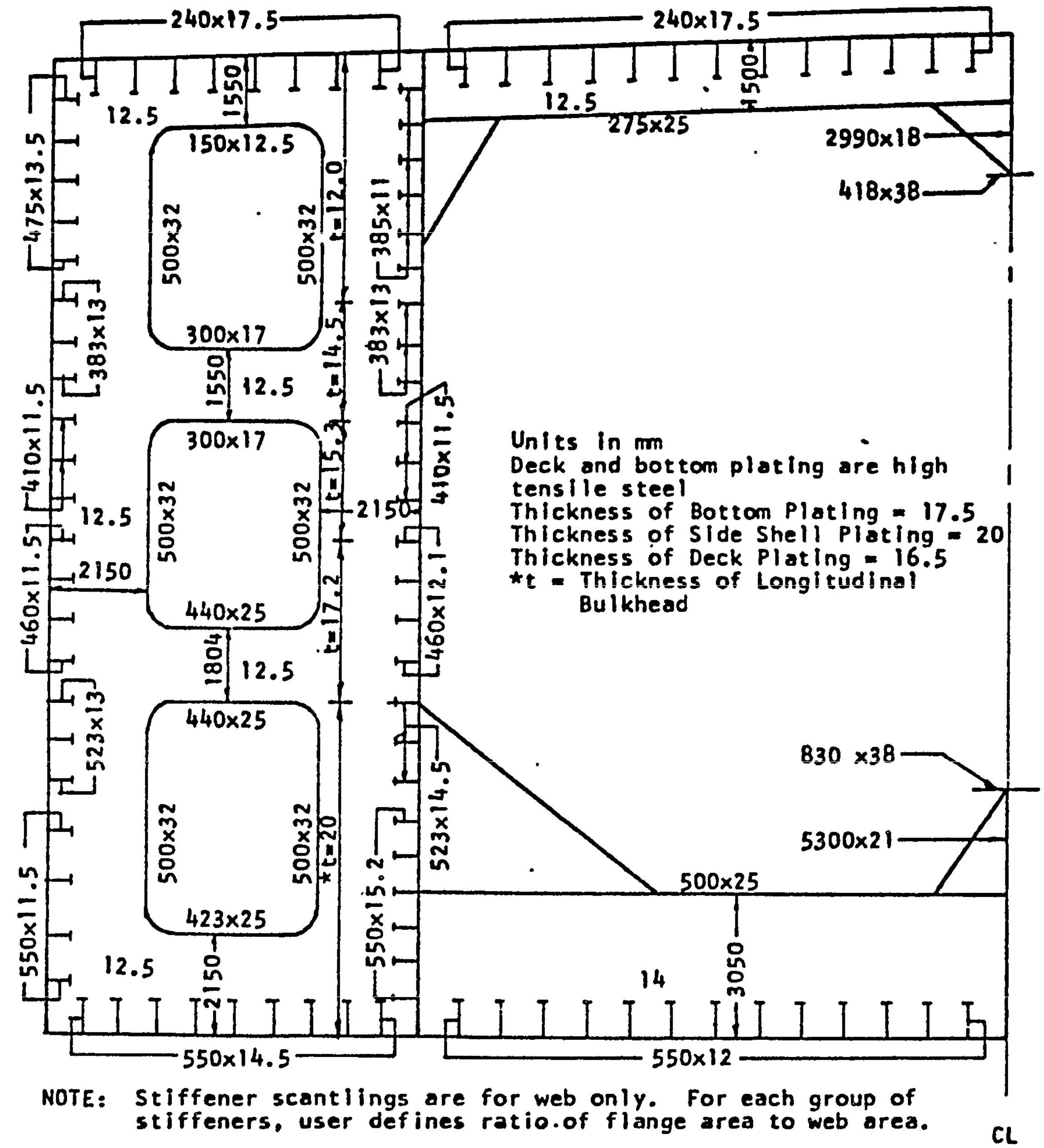


Fig. 6 Initial tanker scantlings

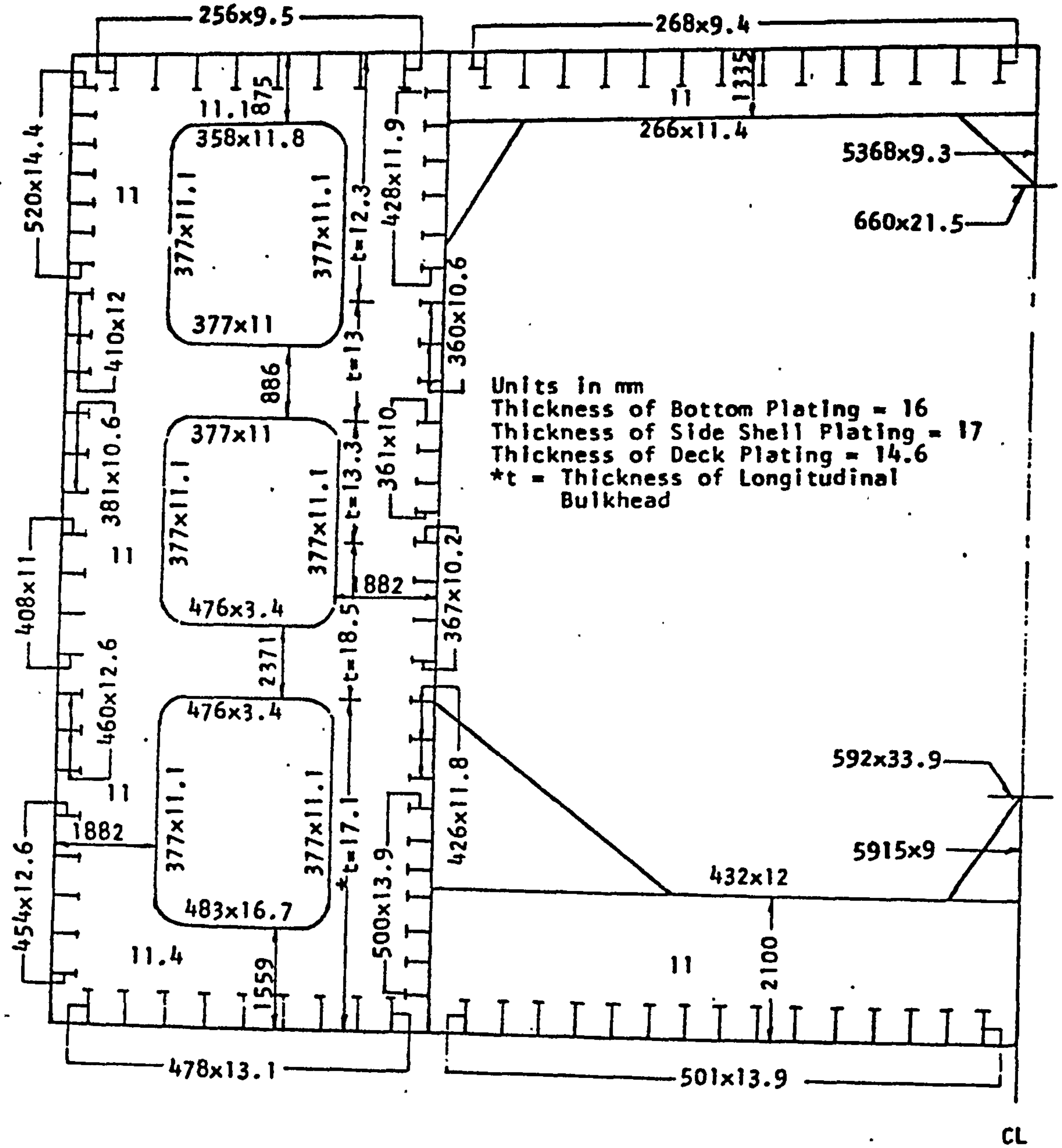


Fig. 7 Final tanker scantlings

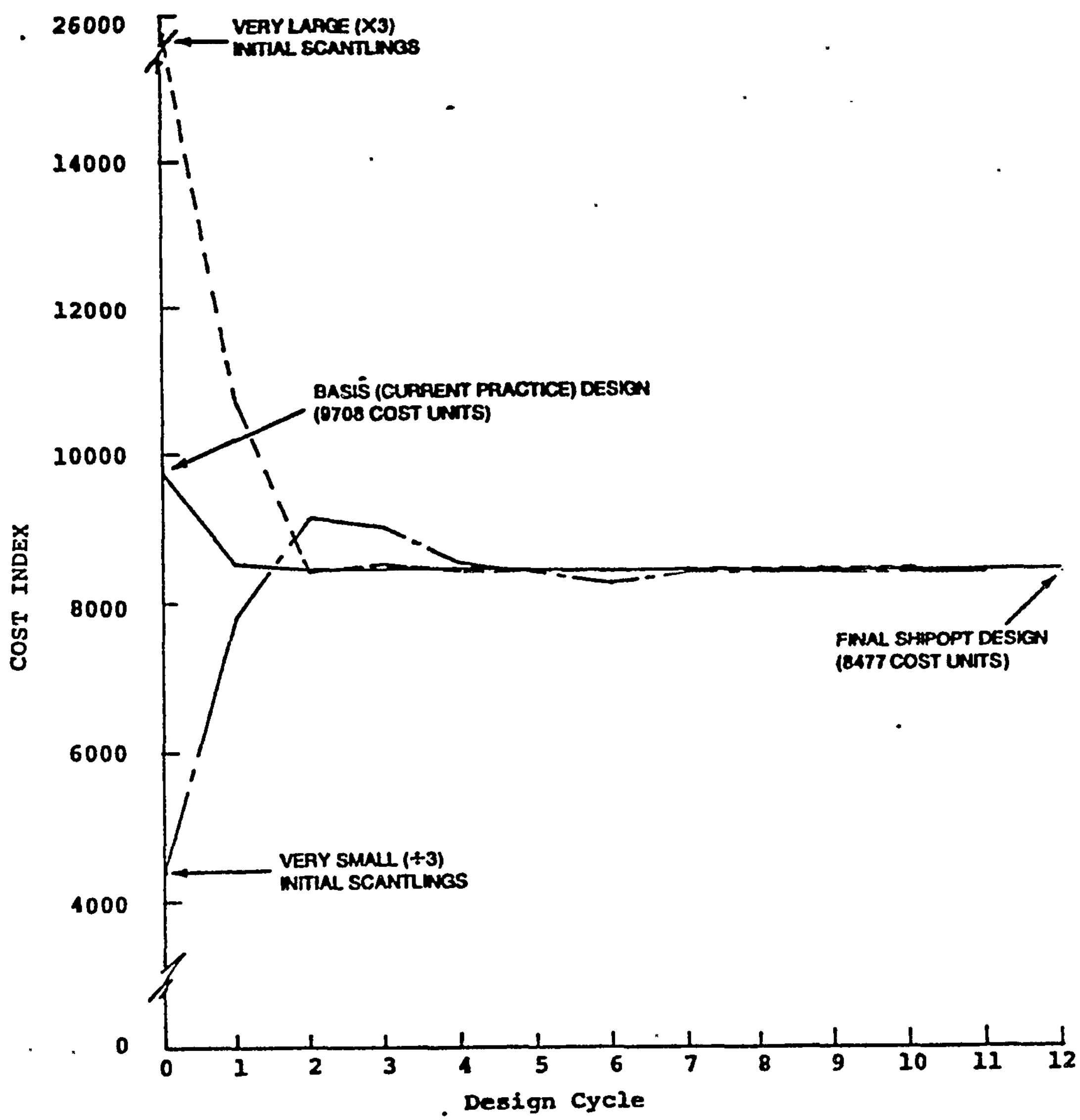


Fig. 5 Convergence and stability of SHIPOPT

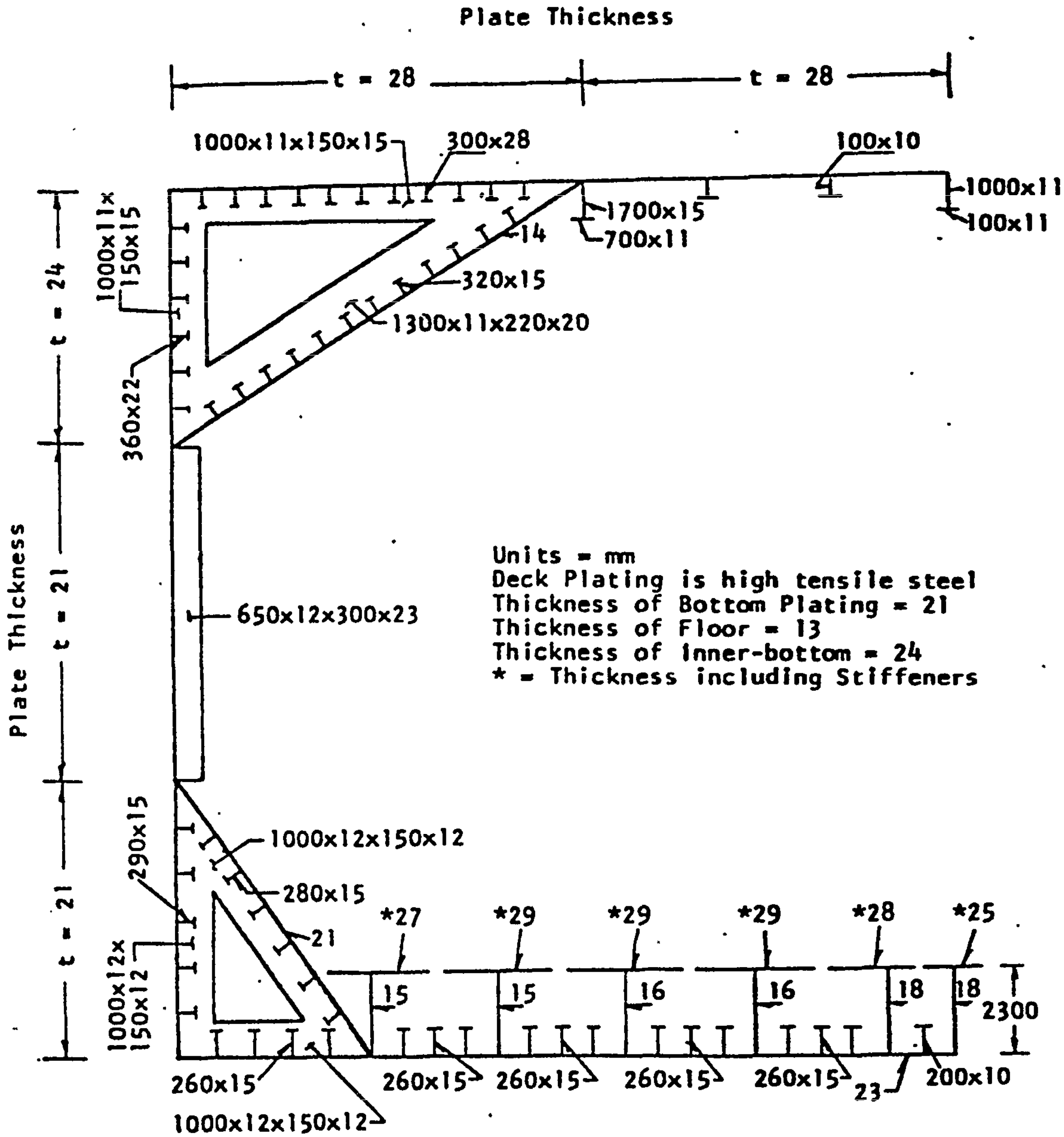


Fig. 9 Initial bulk carrier scantlings

NOTE: Stiffener scantlings are for web only. For each group of stiffeners, user defines ratio of flange area to web area.

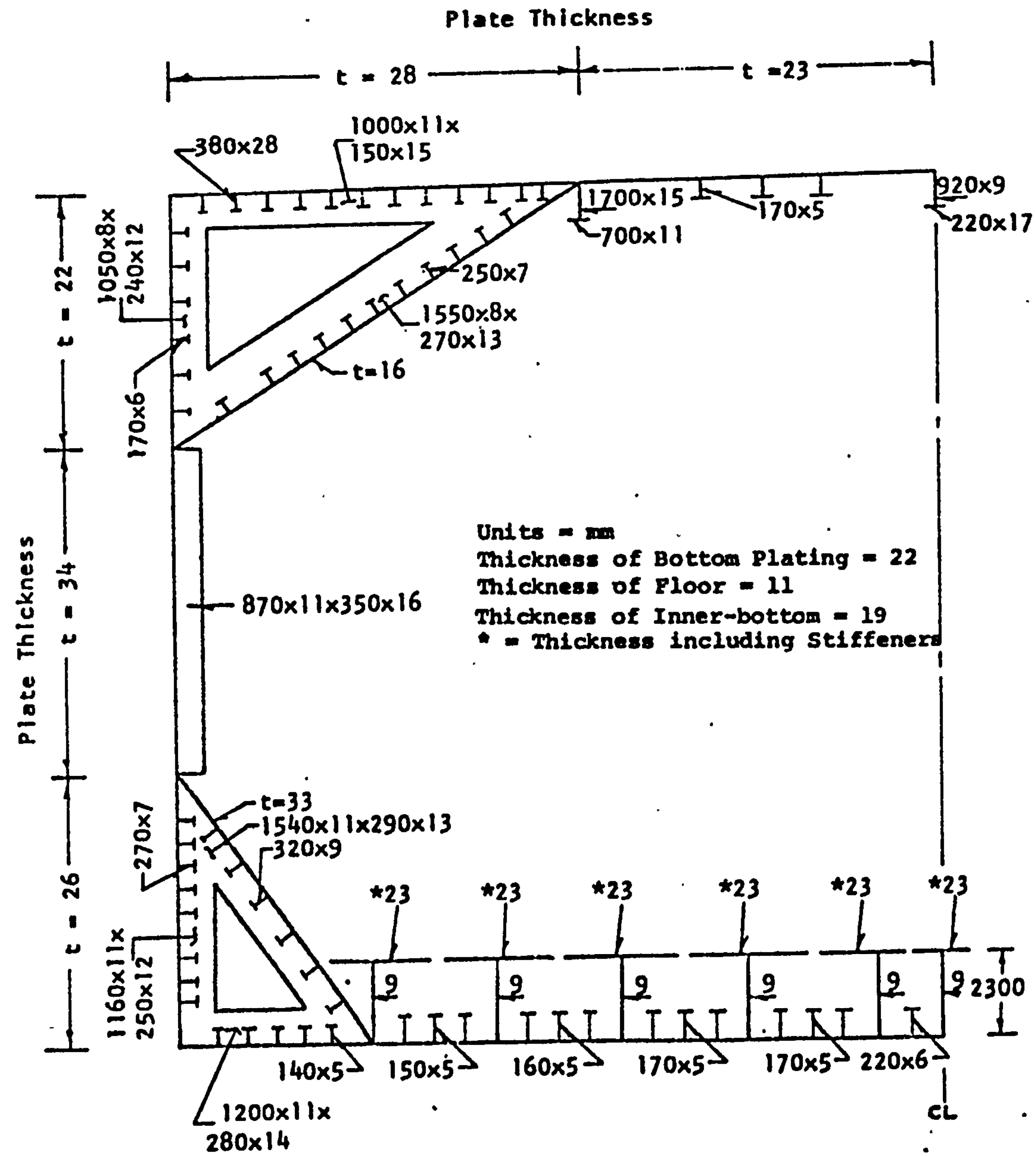


Fig. 10 Final bulk carrier scantlings

HARDWARE

1) MAIN FRAMES

2) "SUPER-MINI ,

ACCESSIBILITY

1) OWEN HUGHES

2) GIANNOTTI & ASSOCIATES

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